2.2 Geological Investigations

2.2.1 Aims

- To locate and characterise potential hydrogeologically relevant geology and structures such as the weathered zone and palaeo-channel at the top of the granite, the basal conglomerate and the argillaceous impermeable layers in the sedimentary rocks.
- To characterise geologically identified, potential water-conducting features in the sedimentary rocks and the upper part of the granite.
- To acquire spatial distribution, geometry and mineralogy of fracture data for geochemical investigations.
- To check and improve the existing conceptual geological model, with emphasis on the inferred NNW fault.

2.2.2 Work performed

Core handling: After cores were extracted from the core barrel, these were handled under the care and responsibility of the field geologist. A reference line was drawn on the core, as continuously as possible from the previous core run, to orient cores sequentially. Cores were cut basically every metre along the borehole axis unless an important feature straddles the planned cut line. In that case the core was cut above and below the feature, then regular cutting resumed. Cores were put into specially made core boxes that can be sealed to minimise alteration by oxidation and drying. The cores were surveyed with a scintillometer to identify targets for geochemical sampling, and to predict the occurrence of the unconformity*. After the core description and photography, the lid was sealed and air in the box was exchanged with inert gas (Ar). The entire core from MSB-2, and anomalous parts of the gamma survey in MSB-1, 3 and 4 are potential targets for geochemical sampling. A two hour limit was set from core recovery to sealing of core boxes.

On-site core description and photographing: All recovered core were described fully at 1/20 scale by the contractor following the method specified in JNC's core logging manual. The following items were included in the description; drilling length along borehole axis, lithofacies (log), rock type, texture, clastic particles and phenocrysts (mineral, size, and shape), mafic mineral content, alteration, fracture density, location and dip of fractures (log), shape of fracture, structure on fracture plane, nature of alteration products along fracture, width of fracture and mineralogy of fracture filling materials. Such items as weathering, RQD and rock mass classification were not included in the on-site descriptions. Depths where the core was cut for storage were also recorded. Profiles including this information will provide basis for other investigations.

Images of all cores were taken using a camera to preserve visual geological and structural information. All images include a scale and a colour chart. Each image includes up to three, 1m long (or less) lengths of core.

* The rationale for this method is the well known occurrence of uranium mineralisation in these sedimentary rocks, as is well documented in [3].

2.2.3 Results

- Overviews of the geological characterisation are shown in lithostratigraphical columns with simple descriptions (Figures 15, 16, 17 and 18). Geological profiles are also shown in Figure 19. All the core images are given in Appendix I.
- The Akeyo Formation† and the Toki Lignite-bearing Formation* were encountered in all boreholes. The Akeyo Formation consists mainly of tuffaceous sandstones, mudstones and conglomerates. The basal conglomerate contains granules to pebbles of mudstone, chert, quartz porphyry and granite within a matrix of tuffaceous materials. The underlying Toki Lignite-bearing Formation consists mainly of arkosic sandstones, mudstones and conglomerates and is intercalated with thin lignite layers. The basal conglomerate contains pebbles to boulders of granite and quartz porphyry within a matrix of arkosic materials.
- Predicted argillaceous layers above the basal conglomerate of the Akeyo Formation are not distinctly confirmed at the same horizon in each borehole. Scattered pumice particles in tuffaceous sandstones and tuffs are slightly altered by weak to moderate argillisation.
- The granite basement is medium-grained biotite granite. Thickness of the weathered granite ranges between 0.3 m, 2.4 m and 12.9 m in MSB-1, 2 and 3, respectively. There is no weathered granite in MSB-4.
- A fault was intersected at 87.7 to 92.2 mabh by MSB-3. The fault core at 91.2 to 92.2 mabh is 0.3 m in width and consists of fault gouge and fault breccia. The fracture zone at 87.7 to 91.2 mabh above the fault core has a high fracture density. Based on the orientation of the nearby fracture observed by BTV, the fault is inferred to strike N21°W and dip westward at 87 degrees. Also, the vertical displacement, east down is inferred to be about 3 m from the correlation with the lithology in MSB-2.
- The fault in MSB-3 is correlated with the NNW fault seen in nearby drifts and at the surface, because they are similar in strike, dip, thickness and vertical displacement, and because they line up with the seismic anomalies (Figure 20). Therefore, the NNW fault is inferred to extend straight toward NNW, based on its strike and dip in MSB-3, rather than along the N7°W lineament trending to the north of the MIU Construction Site.
- Densities of the steep angle fractures at approximately 30 to 90 mabh in MSB-1 and at approximately 80 to 100 mabh in MSB-3 are greater than in other sections in all boreholes. Subhorizontal fractures with iron oxy-hydroxides are remarkably abundant above a depth of approximately 10 mabh in MSB-1 and above a depth of approximately 20 mabh in MSB-2. Also, fewer fractures occur in the weathered granite in MSB-1 and 2; steep angle fractures with clay and chlorite filling and subhorizontal fractures are predominant in MSB-3, likely due to borehole orientation as much as geology.
- Potential water-conducting features were identified at 29.89 mabh, 32.32 mabh, 60.59 mabh and 67.87 mabh in the tuffaceous sandstone of the Akeyo Formation in MSB-1, where 100 % fluid loss occurred during drilling. They are single fractures at moderate to steep angles and are filled with clay and/or pyrite. Also, steep angle fractures with clay and chlorite fillings occur at the depths in which fluid logging anomalies were identified in the upper part of the granite in MSB-2 and 3.

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† The boundary between these formations is based on [4]. The Akeyo Formation in his report includes the Upper Formation of Toki Lignite-bearing Formation described in [3] or the Hongo Formation in [5].

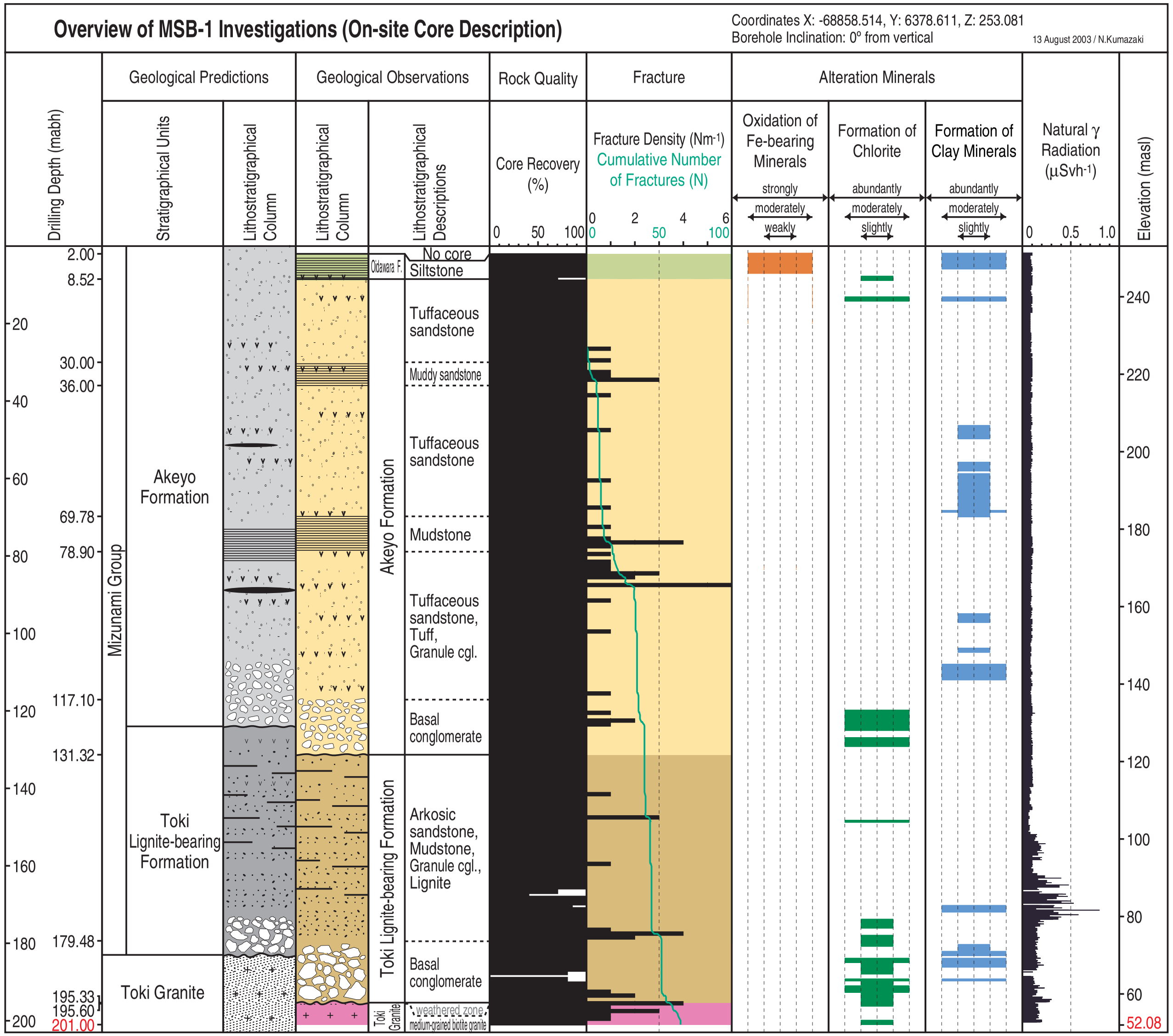


Figure 15 Overview of MSB-1 geological investigations

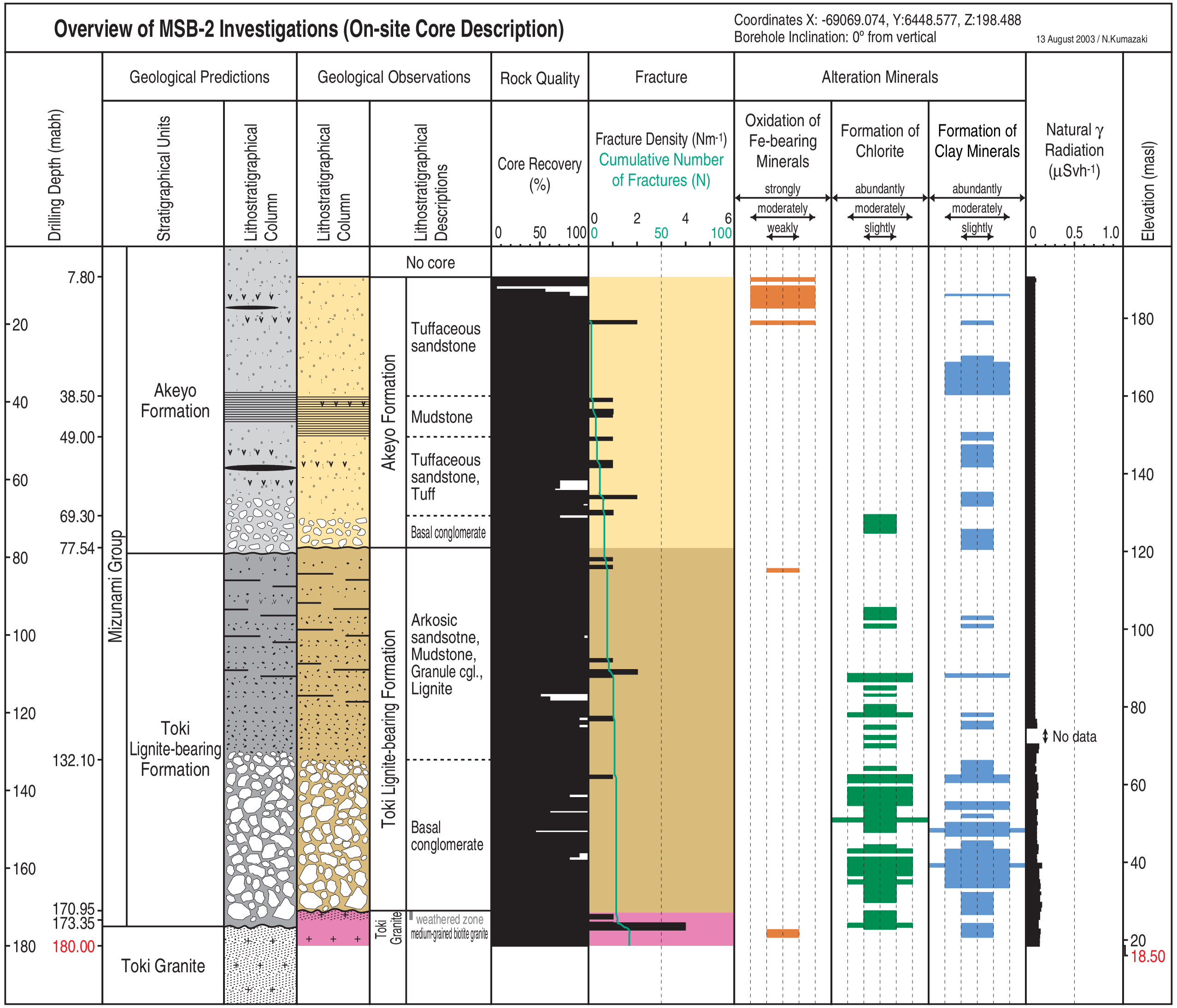


Figure 16 Overview of MSB-2 geological investigations

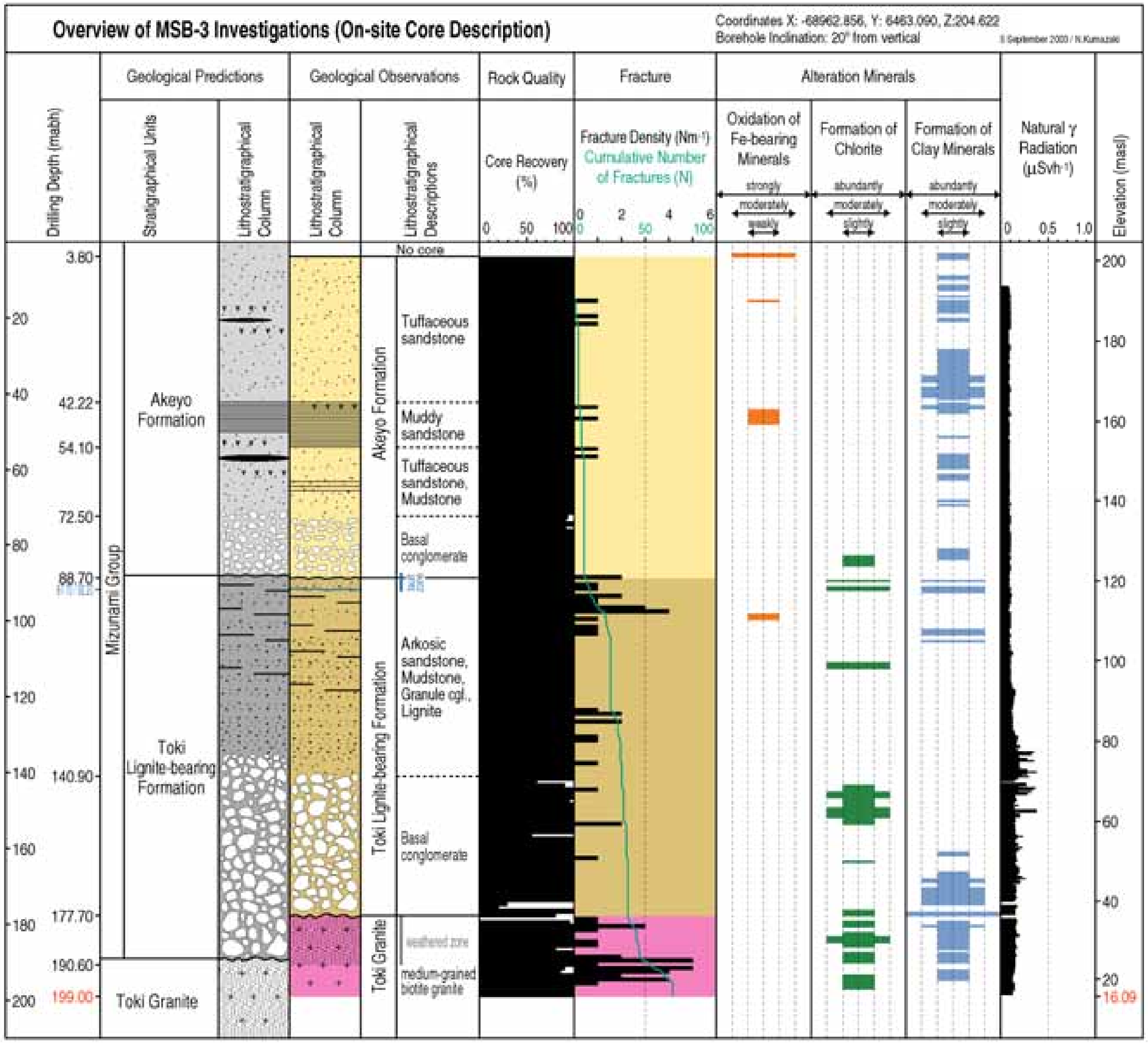


Figure 17 Overview of MSB-3 geological investigations

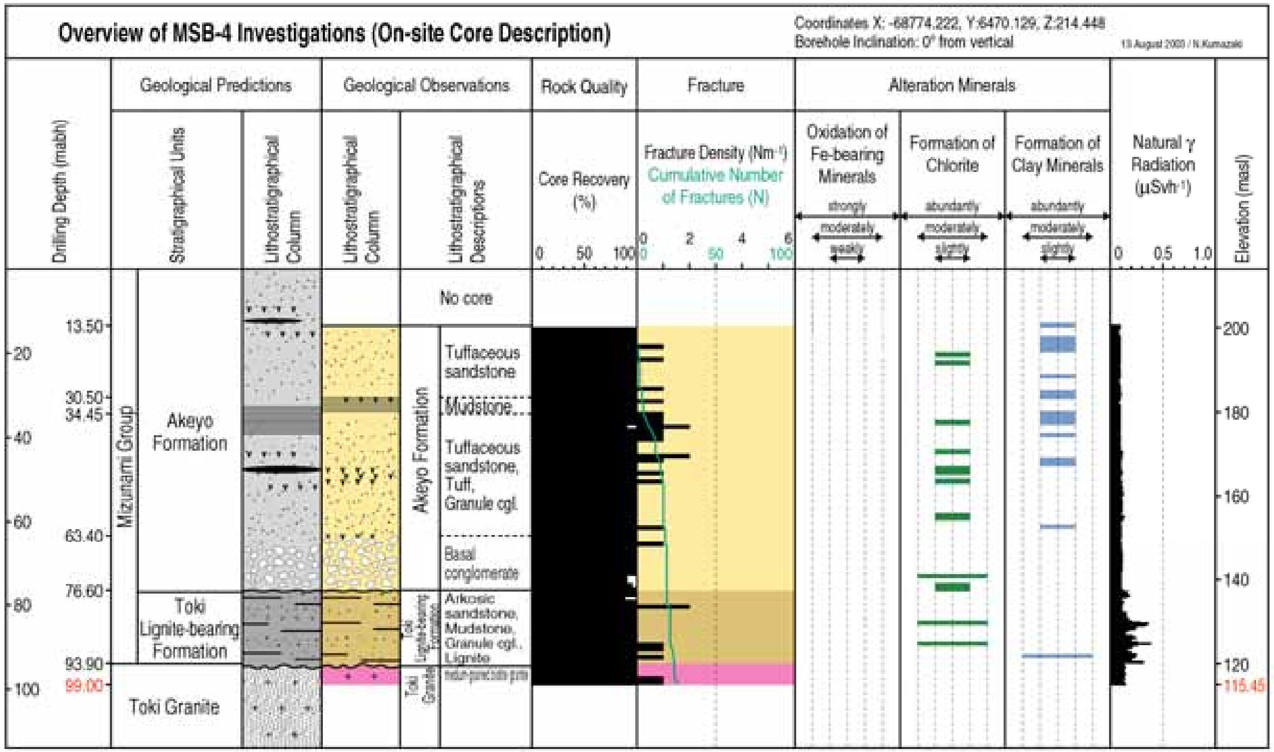
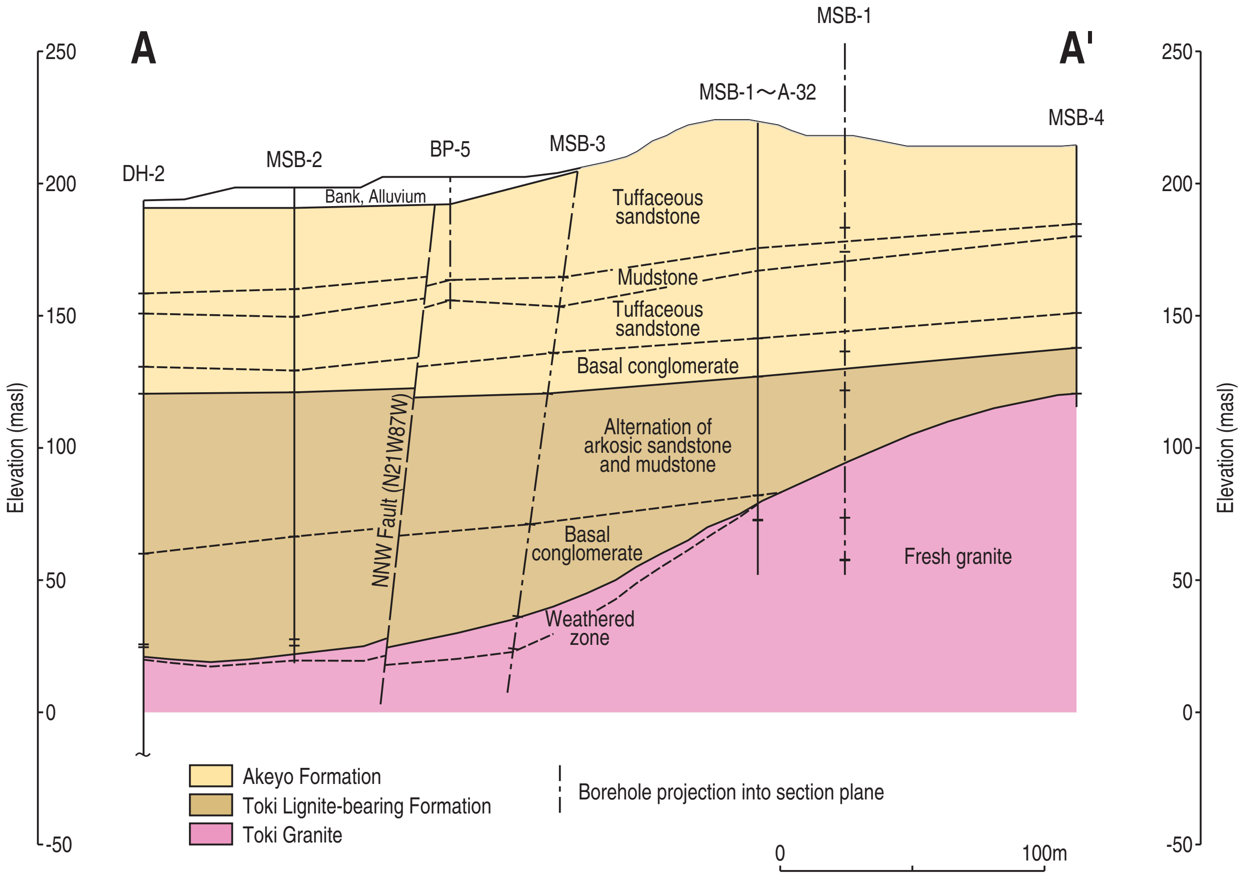


Figure 18 Overview of MSB-4 geological investigations



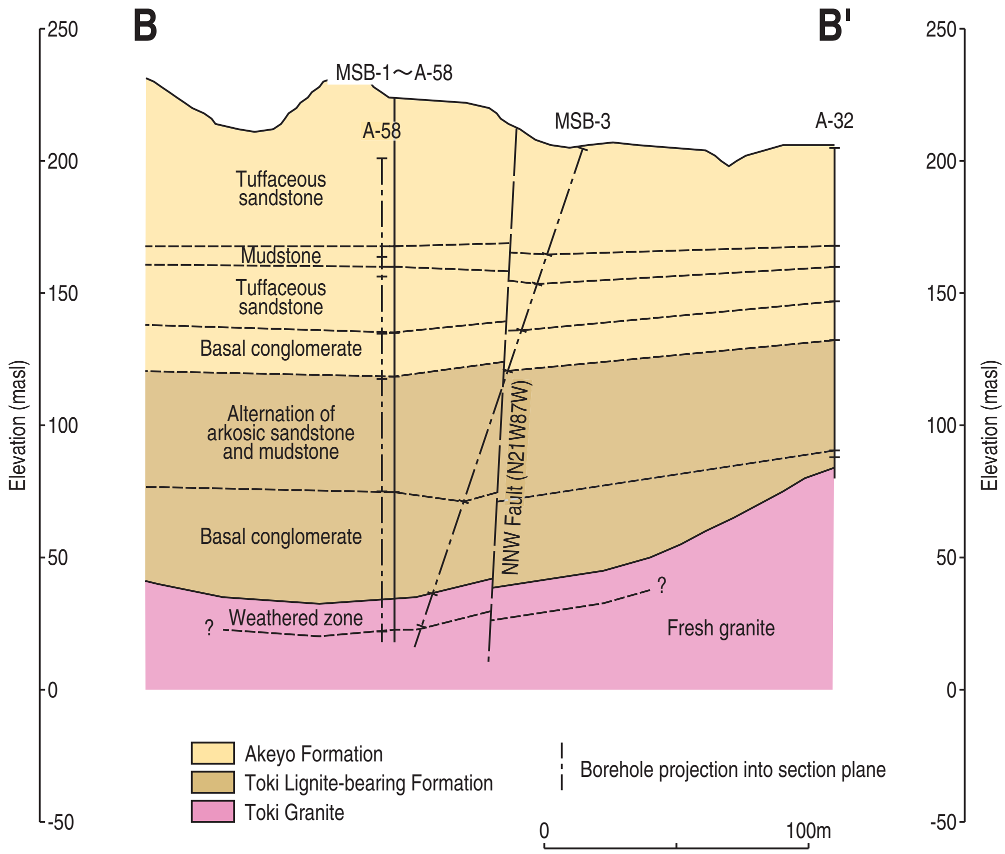


Figure 19 Geological cross sections across the MIU Construction Site (Refer to Figure 20 for the location of cross sections)

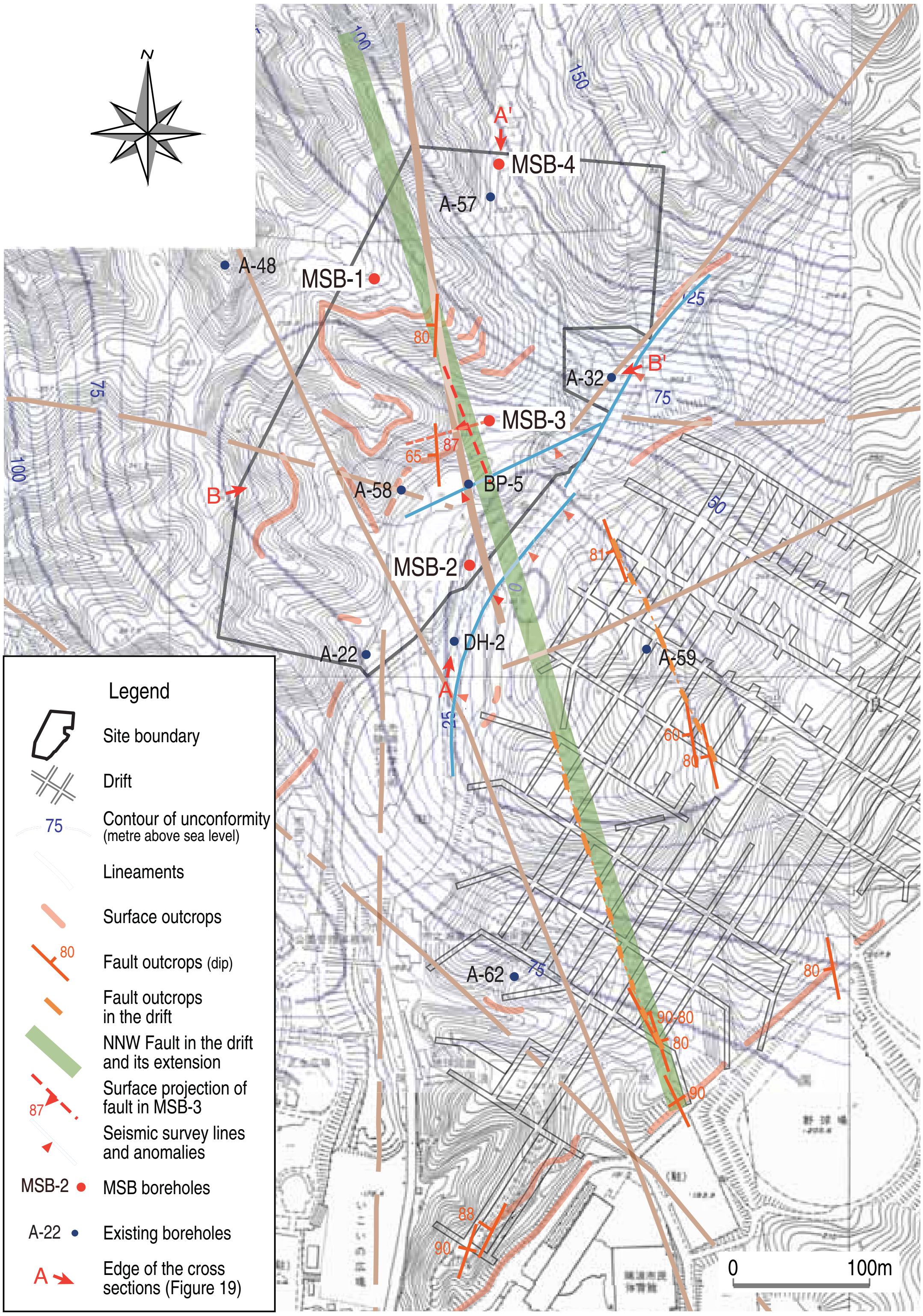


Figure 20 The occurrence of the NNW fault at the MIU Construction Site

- Predicted and actual depths of lithological boundaries are shown in Table 3. The actual depth and thickness of the basal conglomerate were consistent with the predictions. The actual depth of the unconformity of the Toki Lignite-bearing Formation and the Toki Granite was consistent with the prediction in MSB-2 and 4, 12 m deeper in MSB-1 and 11 m shallower in MSB-3.

Table 3 Predicted and actual depths of lithological boundaries

Lithological boundary		Borehole			
		MSB-1	MSB-2	MSB-3	MSB-4
Top of basal conglomerate in Akeyo F.	Predicted (mabh)*	107	66	71	66
	Actual (mabh)	117	69	73	63
Bottom of basal conglomerate in Akeyo F.	Predicted (mabh)*	124	80	88	77
	Actual (mabh)	131	78	89	77
Top of basal conglomerate in Toki Lignite-bearing F.	Predicted (mabh)*	173	133	135	-
	Actual (mabh)	179	132	141	-
Unconformity (Top of granite)	Predicted (mabh)*	183	175	189	94
	Actual (mabh)	195	171	178	94
Bottom of weathered zone in Toki Granite	Predicted (mabh)*	203	195	210	114
	Actual (mabh)	196	173	191	-

*: Refer to the Working Programme [2]. Depths of bottom of weathered zone in Toki Granite were predicted by considering the maximum thickness (20m) in DH-series (RHS Project) and MIU boreholes.

2.2.4 Evaluations

- Data on geology such as the weathered zone and the palaeo-channel at the top of the granite and the basal conglomerates in the sedimentary rocks was acquired.
- Geologically identified, potential water-conducting features in the sedimentary rocks and the upper part of the granite were characterised.
- Data on the spatial distribution, geometry and mineralogy of fractures in the sedimentary rocks and the upper part of the granite were acquired.
- Geological structures such as the NNW fault, the weathered zone and palaeo-channel at the top of the granite and the basal conglomerates in the sedimentary rocks were located and characterised, to improve the existing conceptual geological model.

2.2.5 Lessons learned

- The predicted maximum thickness of 20 m of weathered granite was an overestimate. Investigation programmes in future should consider a method to estimate thickness of weathered granite based on a correlation deduced from a statistical analysis, within the constraints imposed by ability to acquire a data set that is statistically valid.
- At least in this site, use of a scintillometer to detect gamma anomalies as precursors of the unconformity were successful in providing an indication of proximity to the unconformity. This was useful as a signal to stop drilling and perform the required hydraulic tests above the unconformity.
- Less relevant data such as weathering, RQD and rock mass classification need not be recorded in the field to save time.